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RESULTS FROM RADIATION MONITORING EQUIPMENT EXPERIMENT ON STS-11

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STEVEN E. CASH

14 MARCH 1985

FINAL REPORT.

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The results from the Radiation Monitoring Equipment (RME) experiment, flown onboard STS-11 are presented and discussed. The RME consists of the HRM-III gamma ray counter and PRM neutron/proton dosimeter. The gamma ray data agree with data from previous flights. Increases in count rates are observed when the Orbiter is in the Southeast Asian Anomaly. Neutron/proton dosage is consistent with NASA predictions for STS-11.

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SUMMARY

The Radiation Monitoring Equipment (RME) was flown on STS-11 Space Shuttle Mission for the purpose of testing a concept for in-cabin, real-time crew dosimetry, and for the purpose of obtaining time resolved gamma-ray background data and neutron/proton background data. The RME consists of two instruments, EG&G HRM-III gamma-ray counter and EG&G Pocket REM Meter (PRM) neutron/proton dosimeter. The HRM-III was operated by the astronaut crew four times during the mission, with each operation lasting 52.5 minutes. The PRM was operated twice during the mission with each operation lasting a minimum of 15 hours.

The results from the HRM-III operations were plotted as a function of time and as a function of ground position. The data show large increases in count rate during the periods when the Orbiter was in the East Asian Anomaly. These data are consistent with data obtained from other missions.

The PRM results are displayed in tabular form. The average dose rate from these operations is .359mrem/hr ($(2.84) \times 10^{-5}$ rad/hr). The total mission neutron/proton dosage predicted by these readings is approximately 60.30mrem (4.77mrads).

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

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SECTION I

INTRODUCTION

This report presents the results of the Radiation Monitoring Equipment (RME) experiment flown on STS-11. The objectives of the RME experiment are two-fold. The first objective was to exercise our ability to fly small quick reaction payloads on the Space Shuttle. The RME tested the feasibility of using state-of-the-art dosimetry equipment that was not originally designed for orbital application for in-cabin, real-time crew dosimetry. The second objective of the experiment is to obtain time resolved gamma-ray background data and neutron/proton background data.

The first objective was partially met during the flights of STS-6 and STS-8 (ref 1, ref 2). The RME was flown for the first time on STS-6 and a limited amount of data were taken. The quality of the data was sufficient to convince us that the instruments will work in space, and, more importantly, that the crew can operate them and obtain meaningful data. Longer operations were required to fully meet the first objective since the instruments were not utilized to their fullest extent during the STS-6 mission. STS-8 provided the first opportunity for long periods of operation.

The second objective was also achieved, in part, during the STS-6 and STS-8 missions. The neutron/proton dosimeter, EG&G's Pocket REM Meter (PRM), was operated for sufficiently long periods of time and gathered meaningful background data. During STS-6, the gamma-ray counter, EG&G's HRM III, was operated for only 10 seconds each time it was activated and did not yield enough background data to meet the second objective. During STS-8, the HRM-III was operated seven times for 52.5 minutes per operation. This yielded significant results.

STS-11 provided another opportunity to further both objectives of the RME experiment. The HRM III was operated four times with each operation lasting 52.5 minutes. The PRM was operated twice with each operation lasting a minimum of 15 hours.

SECTION II

EQUIPMENT

HRM-III.

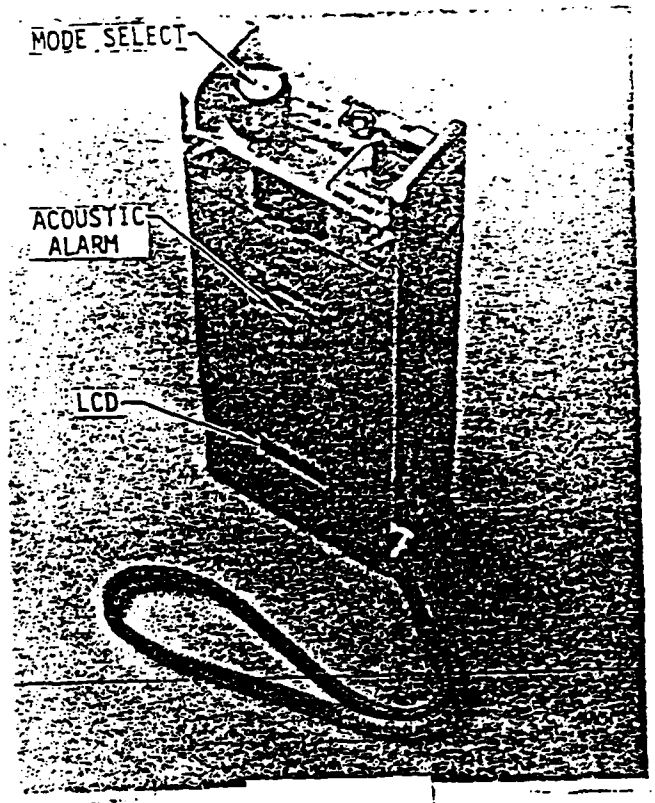
The HRM-III (Figure 1a) (ref 2) is a hand-held gamma-ray counter. It weighs approximately one kilogram (2.2 pounds) and is about the size of a small cassette recorder. The circuitry is all solid state and microprocessor controlled. The detector is a mercuric iodide (HgI_2) crystal with a detection threshold of 100keV.

The HRM-III has 105 internal memories that can store counting data for playback at a later time. These memories are filled with the average counts obtained during a user determined time interval. The interval can vary from 1/3 of a second to 33 seconds. Playback of the stored data is accomplished through a liquid crystal display (LCD) on the HRM-III. This record-playback feature allows for a time-history of the gamma-ray counts without having a user continually monitoring the instrument. (For a more complete description of the HRM-III, see references 1 and 2).

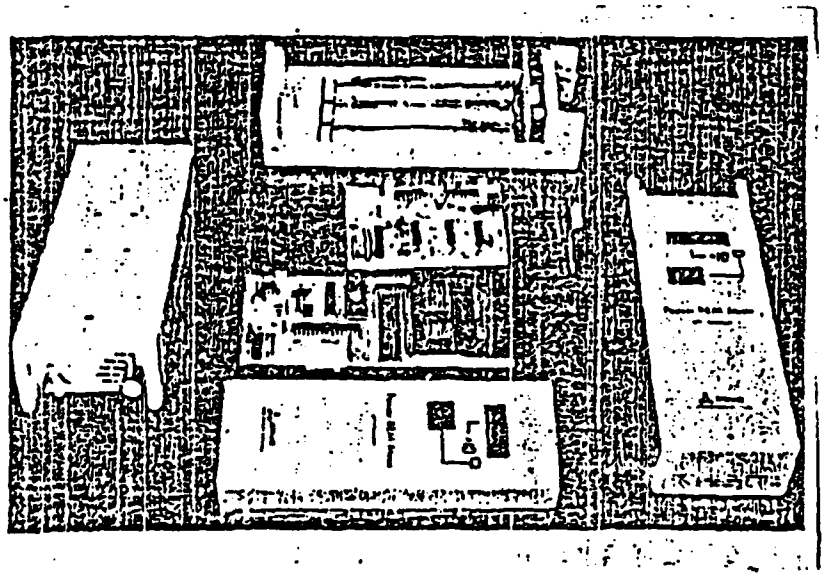
PRM.

The PRM (Figure 1b) (ref 3) is a hand-held neutron/proton dosimeter. It weighs approximately one kilogram (2.2 pounds) and is somewhat larger than the HRM-III. The PRM has microprocessor controlled solid state circuitry. It uses three ionization tubes as detectors. These tubes are surrounded by a tissue equivalent plastic. The associated electronics then produces data in the form of counts, done (rad) and dose equivalent (rem) in real time.

Data are obtained via an LCD. The PRM will read out either hours (elapsed time since turn-on), counts, rads or rems just by changing the position of a rotary switch. The LCD displays the current value of the function (hours, counts, RADs, REMs) chosen and the LCD readout is updated as the value changes. Thus, the PRM is a real time dosimeter (For a more complete description, see references 1 and 3).



HRM-III
FIGURE 1A



PRM
FIGURE 1B

SECTION III

RESULTS

HRM-III.

The HRM-III was operated four times during the mission. Each operation lasted for 52.5 minutes. The HRM-III was setup to fill one memory every 30 seconds. In this configuration, the HRM-III took data over approximately 58% of a 165 nautical mile (nm) (305.6 km) orbit.

The data obtained from the four runs have been plotted two different ways. The first set of plots (Figures 2, 4, 6, and 8) shows average counts per second plotted against time elapsed since instruments turn on. The second set of plots (Figures 3, 5, 7, and 9) shows the average counts per second super-imposed on a map of the world with respect to the Orbiter's ground track (i.e., subpoint).

The data plotted in Figures 2 through 9 show the background counts/second for gamma-rays. The data can clearly be divided into two categories: one for count rate in the Southeast Asian Anomaly; and the other for count rates outside of the Southeast Asian Anomaly. For data taken outside the Southeast Asian Anomaly, the background average count rate is 30 counts/second. For data taken in the Anomaly the average count rate goes as high as 64 counts/second.

There is unfortunately, no easy way to convert these HRM-III counts into a "pure" gamma-ray dose. We are, however, currently exploring the possibility of modifying the PRM to include gamma-ray dosage with neutron/proton dosage.

No calibration is required for the HRM-III since it uses solid state components and detector. The HRM-III that was flown had been checked by EG&G ten months prior to STS-11.

In general, the data exhibit no technical surprises and appear consistent with previous measurements and expectations. Future flights will provide data from different altitudes and orbital inclinations thereby adding to the data base of background data.

PRM.

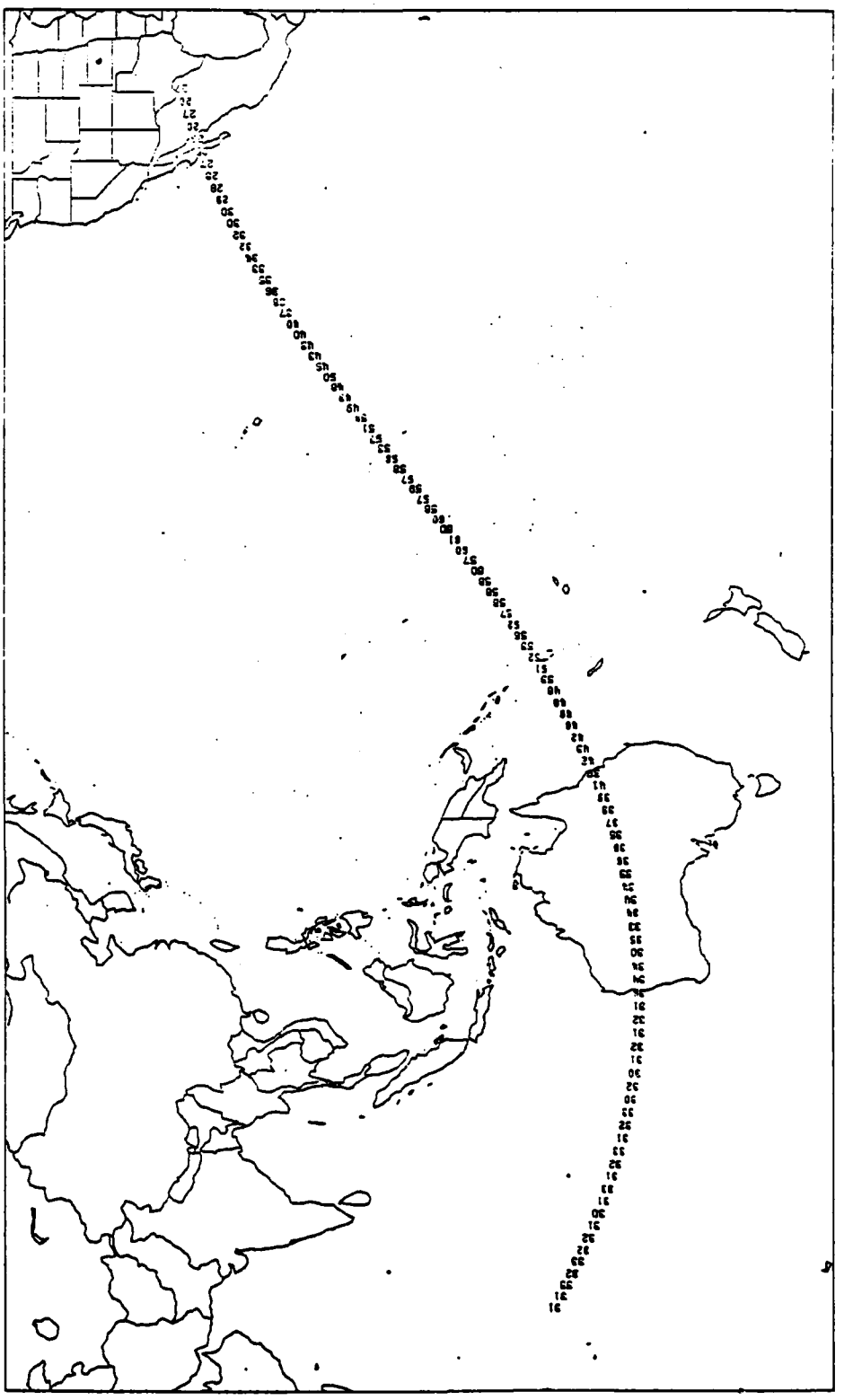
The PRM was operated twice during the STS-11 mission. The first operation occurred at MET 1/07:32:30 and lasted 15.00 hours. The second operation took place at MET 5/03:45:18 and lasted for 15.37 hours. The PRM had no anomalous behavior during either operation.

PRM data is presented in Table 1. The count rate is approximately the same for both operations. Table 2 shows the average dose rate for each operation and the average dose rate for both operations combined. For a seven day mission (more exactly, 7 days, 1 hour, 39 minutes), this would predict a dosage from neutrons and protons to be 60.3m REM or 4.77m RAD.

PRM calibration (ref 1) was performed by EG&G in May of 1983. The PRM was found to be accurate to within 3% during this calibration.

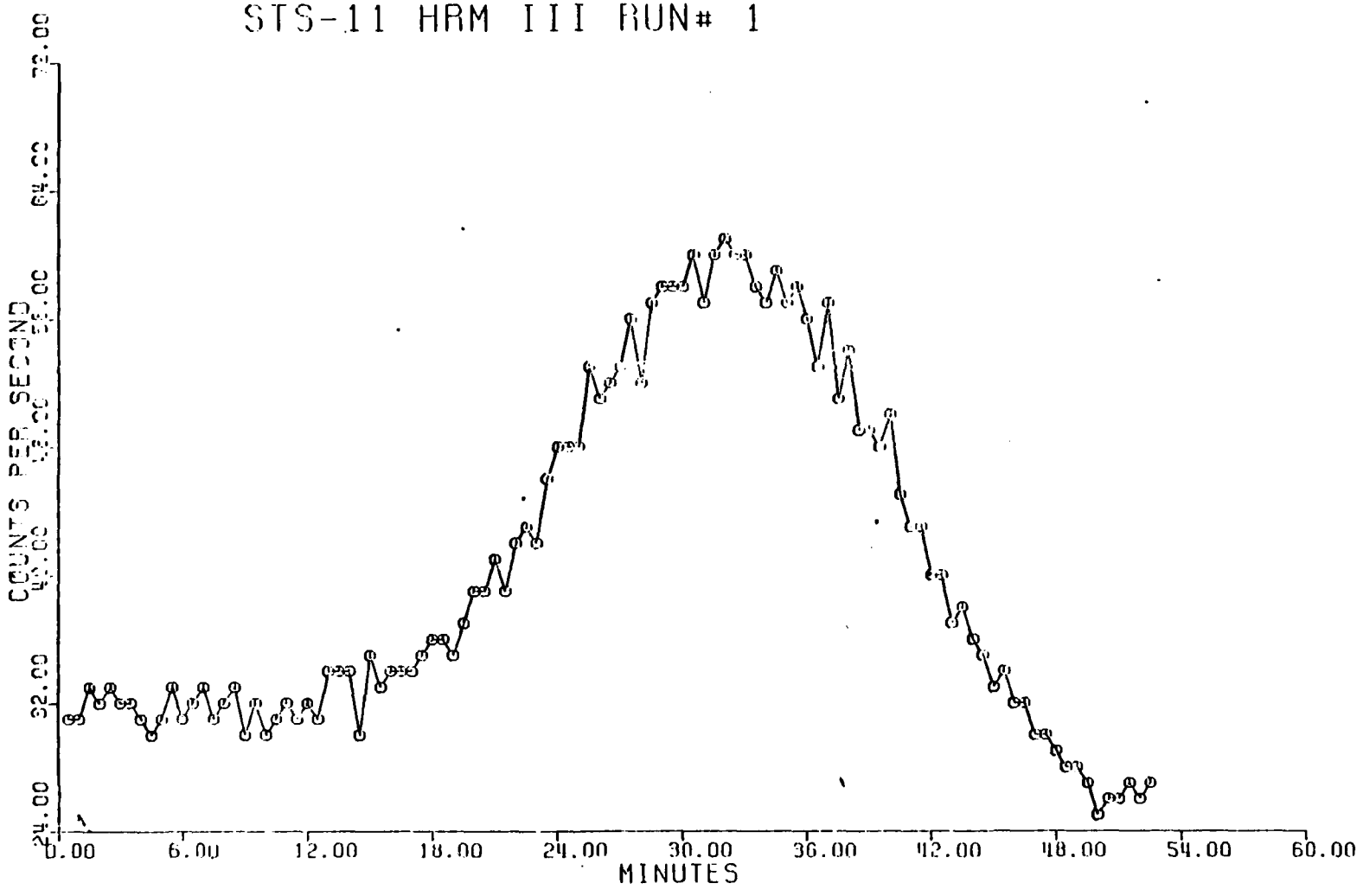
HRM-III

OPERATION NO. 1



STS-11

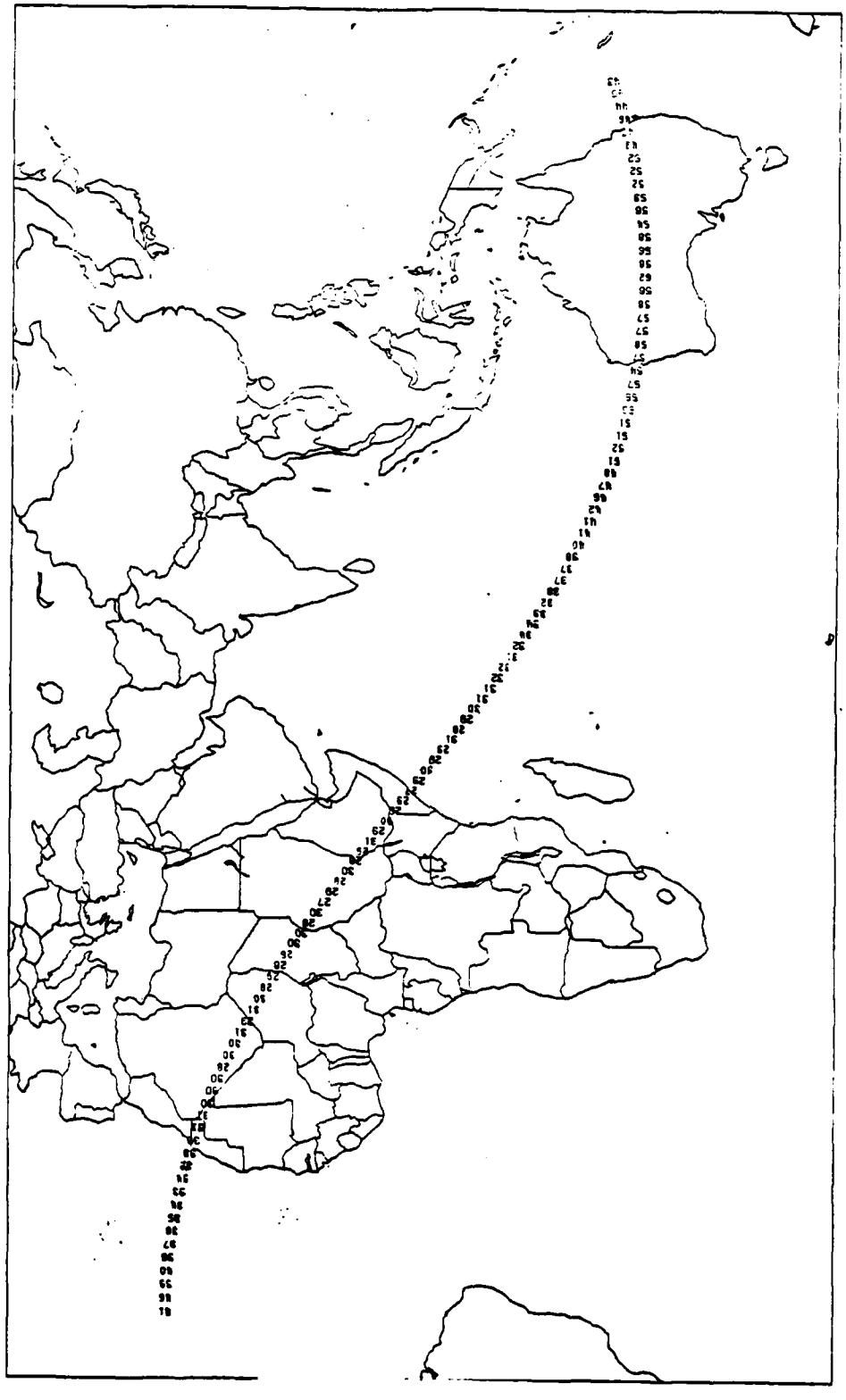
HRM-III GROUNDTRACK
OPERATION #1
FIGURE 2



HRM-III
COUNTS VS TIME
OPERATION #1
FIGURE 3

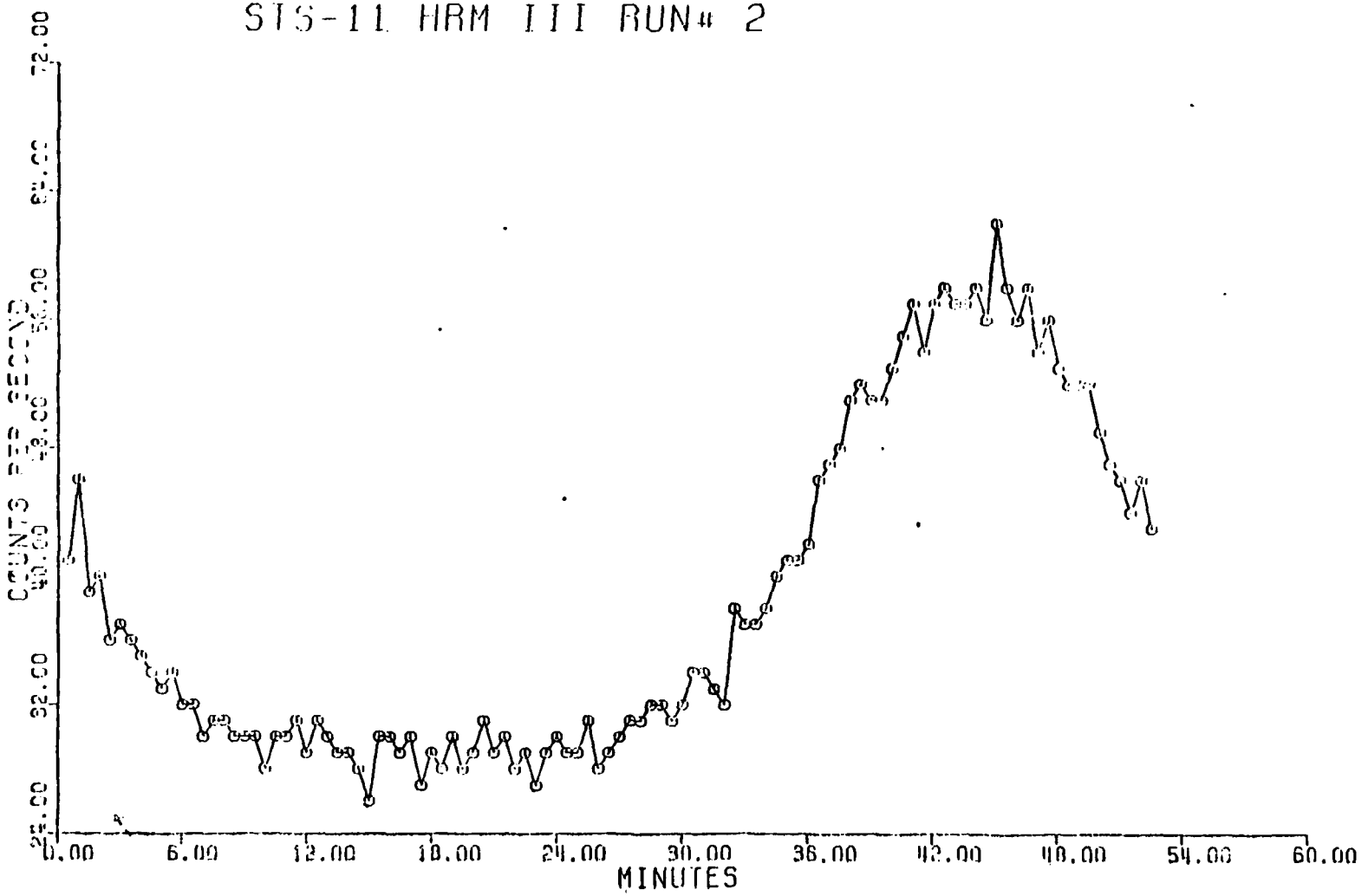
HRM-III

OPERATION NO. 2



STS-11

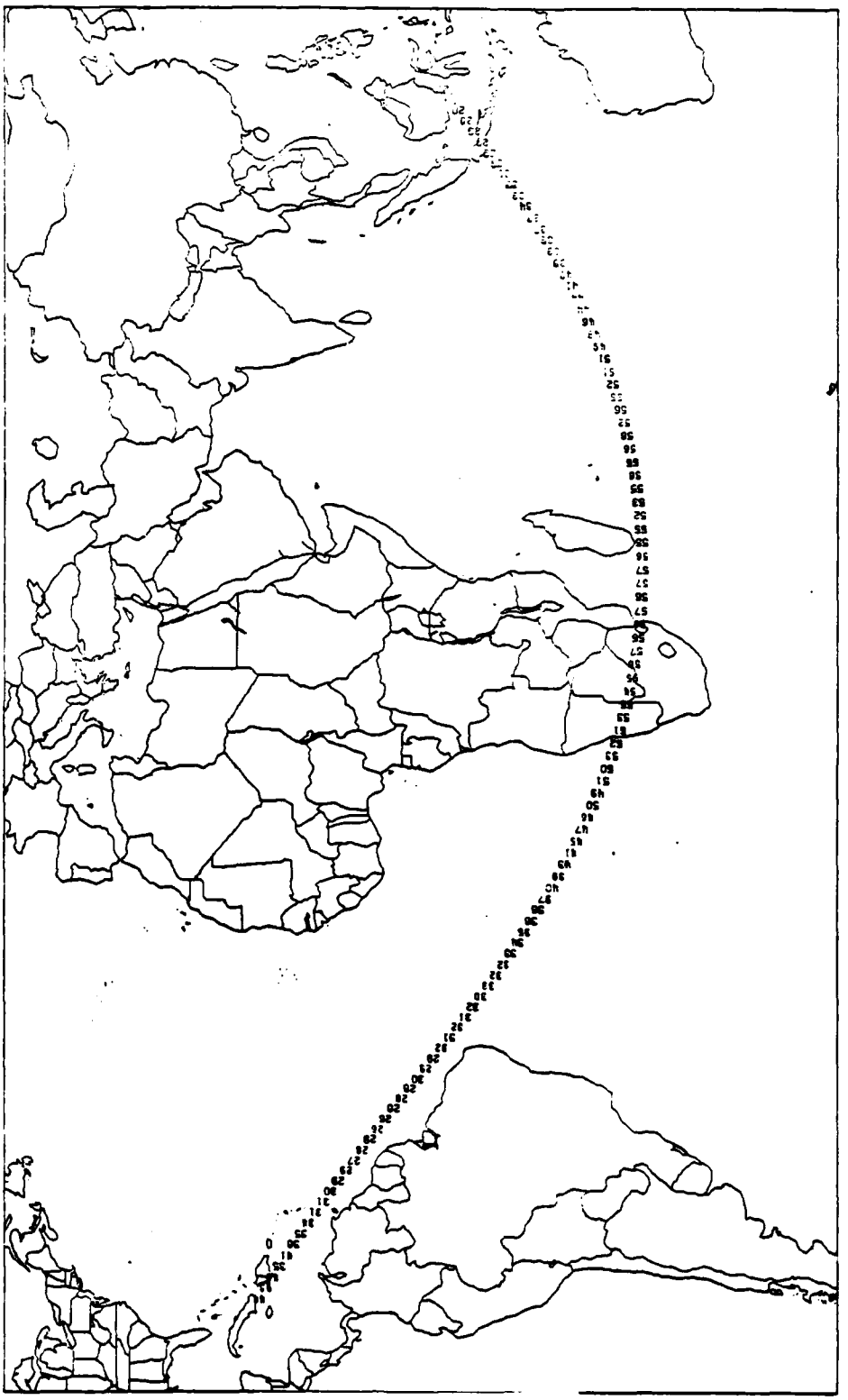
HRM-III GROUNDTRACK
OPERATION #2
FIGURE 4



HRM-III
COUNTS VS TIME
OPERATION #2
FIGURE 5

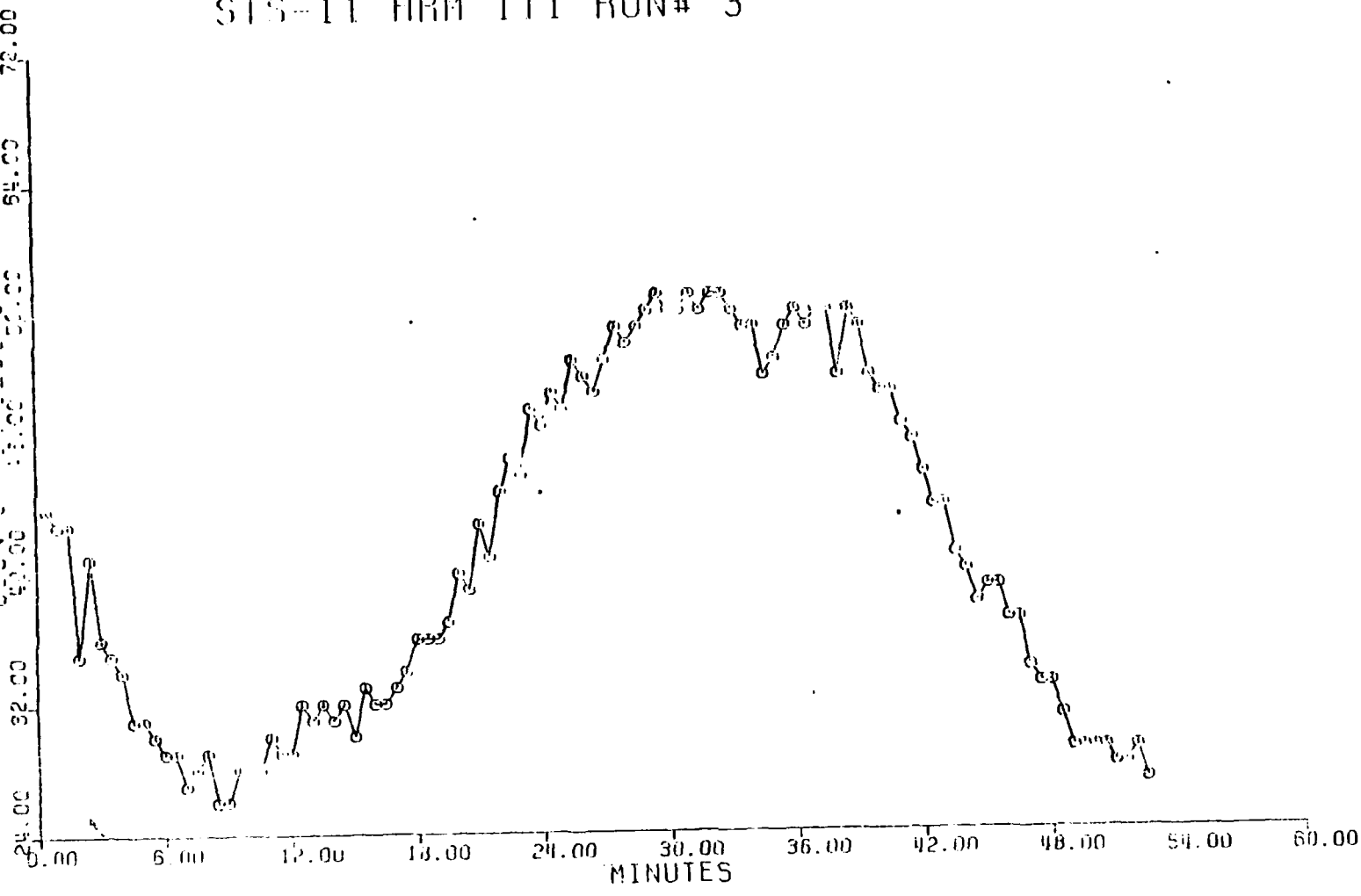
HRM-III

OPERATION NO. 3



STS-11

HRM-III GROUNDTRACK
OPERATION #3
FIGURE 6

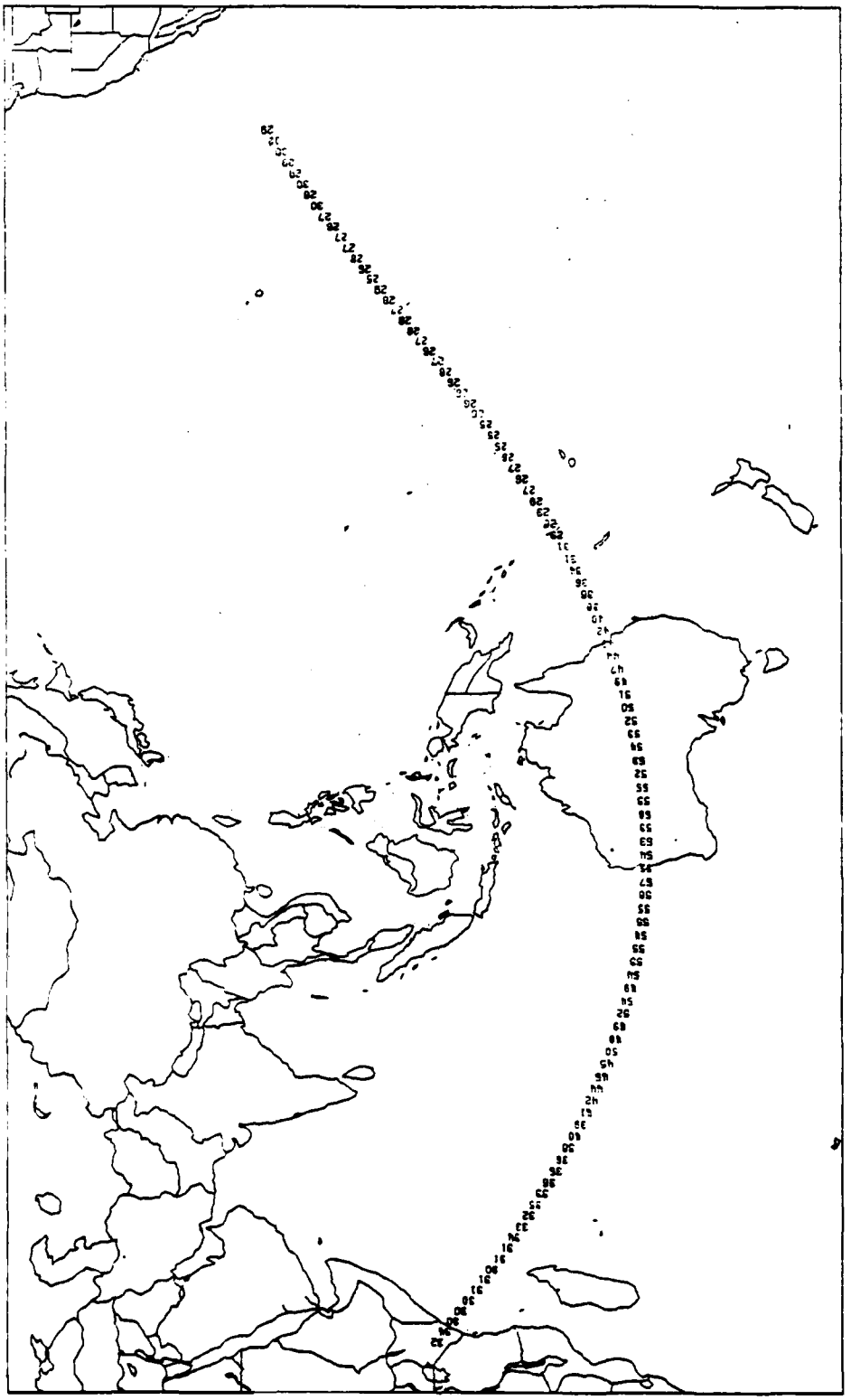


HRM-III
COUNTS VS TIME
OPERATION #3
FIGURE 7

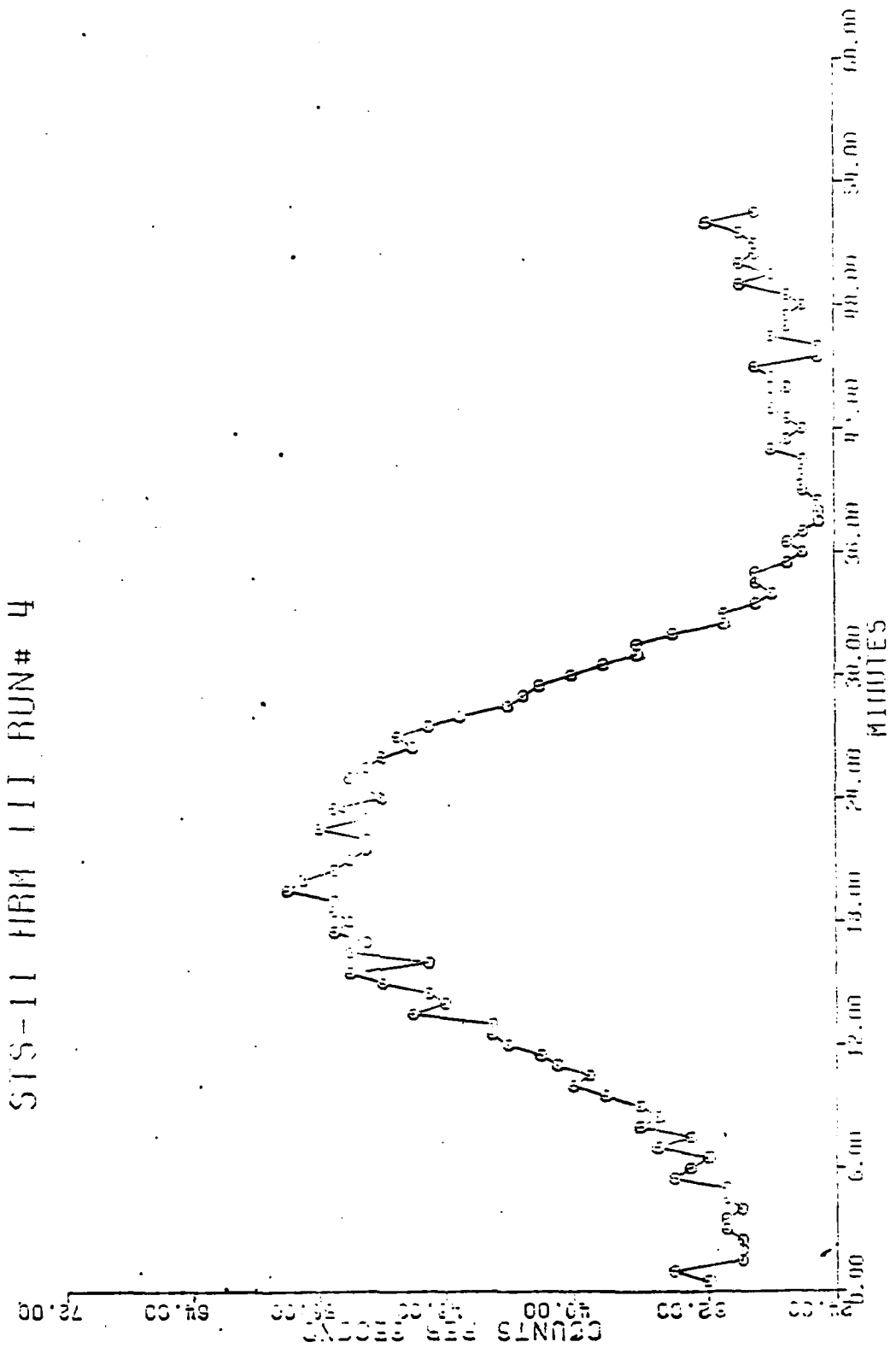
HRM-III

OPERATION NO. 4

STS-11



HRM-III GROUNDTRACK
OPERATION #4
FIGURE 8



HRM-III
COUNTS VS TIME
OPERATION #4
FIGURE 9

TABLE 1

PRM DATA FROM STS-11

RAW DATA

MET	1/07:32:30	5/03:45:19
Counts	1367	1493
Average Count Rate	91.13/hr	97.14/hr
Stdr Dev	± 9.55/hr	± 9.86/hr
rem	5.24 mrem	5.67 mrem
rad	.411 mrad	.451 mrad
Hours	15.00 hrs	15.37 hrs

TABLE 2

PRM DATA FROM STS-11

AVERAGE DOSE RATES

MET	1/07:32:30	5/03:45:19
Dose Rate (mrem/hr)	.35	.37
Dose Rate (mrad/hr)	.027	.029

Average dose rate for both operations:

(mrem/hr) $.36 \pm .008$

(mrad/hr) $.028 \pm .003$

SECTION IV

CONCLUSIONS

The data collected from the RME are consistent with data taken on previous missions. There were no surprises in the data and any variations in the data correspond to natural external sources of radiation (e.g., the Southeast Asian Anomaly).

The procedures used for the RME on STS-11 allowed the crew to employ the full capability of both instruments. Thus, the objective of testing the feasibility of using non-space specific hardware in space in a quick reaction mode was adequately demonstrated. An important point to note here is that the instruments were easily operated and read by the crew and meaningful data were obtained. These instruments are also easily serviced by the crew. The second objective of obtaining radiation background data was also satisfied by this mission.

Future flights of the RME will contribute to the data base on background radiation. Different mission profiles will yield data from different altitudes and orbital inclination. Such a data base will prove useful for planning future space systems, including crew health and safety requirements as may exist in permanently inhabited stations and platforms.

REFERENCES

1. STS-6 Report, (in publishing), AFTAC, Caplan, et al.

2. HRM-III Handheld Radiation Monitor User's Handbook; EG&G Report No. EGGH83-2424 S-347-MN

3. Pocket Neutron REM Meter; W. Quam, T. DelDuca, et al, preprint.

4. STS-8 Report, AFTAC, (in publishing) Madonna, et al.

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PRM

1 Activation & Checkout

Unstow PRM
If second operation, replace, mark and stow used battery
Set Rotary sw - HRS
ON/OFF sw - ON
✓Display counts down from 9:30 and record MET on PRM DATA PAD when Display = 0.00

* If displays show a color is blank, set ON/OFF sw - OFF; replace, mark and stow used battery and repeat step 1 *

Report MET to MCC
Remove PRM (leave ON)

2 Data Recording

8-18 hrs after step 1, unstow PRM
Set rotary switches to appropriate positions and record display outputs on PRM DATA PAD

Set ON/OFF sw - OFF
Stow PRM

PRM DATA PAD

0.00 MET	110 7:32:30 122:32:30	5103:45:19 506:19:10
HRS	15.00	15.37
CNTS	1.367 E (+) 03	1.493 E (+) 03
PAD	04.11 E (−) 04	4.51 E (−) 04
RCM	05.24 E (−) 03	5.67 E (−) 03

DATA PAD FOR
PRM
OPERATIONS

DATA PAD FOR
HRM-III
OPERATION 1
20

11-5

STS-1/FD1

01

INIT MET 02:55:00 HRM A PADS

CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC
0_01	31	0_22	32	0_43	39	0_64	61	0_85	40
0_02	31	0_23	31	0_44	42	0_65	60	0_86	37
0_03	33	0_24	32	0_45	43	0_66	60	0_87	38
0_04	32	0_25	31	0_46	42	0_67	58	0_88	36
0_05	33	0_26	34	0_47	46	0_68	57	0_89	35
0_06	32	0_27	34	0_48	46	0_69	59	0_90	33
0_07	32	0_28	34	0_49	48	0_70	57	0_91	34
0_08	31	0_29	30	0_50	48	0_71	58	0_92	32
0_09	30	0_30	35	0_51	53	0_72	56	0_93	32
0_10	31	0_31	33	0_52	51	0_73	53	0_94	30
0_11	33	0_32	34	0_53	52	0_74	57	0_95	30
0_12	31	0_33	34	0_54	53	0_75	51	0_96	29
0_13	32	0_34	34	0_55	51	0_76	54	0_97	28
0_14	33	0_35	33	0_56	52	0_77	49	0_98	28
0_15	31	0_36	36	0_57	51	0_78	49	0_99	27
0_16	32	0_37	36	0_58	52	0_79	48	0100	25
0_17	33	0_38	35	0_59	53	0_80	50	0101	26
0_18	30	0_39	37	0_60	58	0_81	45	0102	26
0_19	32	0_40	37	0_61	60	0_82	43	0103	27
0_20	30	0_41	39	0_62	59	0_83	43	0104	26
0_21	31	0_42	41	0_63	60	0_84	41	0105	27

SPAS-01 SEE DATA | SPAS-01 BASIC | SPAS-01 VET PAD | SPAS-01 DEACT | SPAS-01 | RME | STU PAD | GAS

HRM DATA PADS

CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC
0_1	41	0_22	30	0_43	30	0_64	32	0_85	58
0_2	46	0_23	31	0_44	26	0_65	38	0_86	57
0_3	39	0_24	29	0_45	29	0_66	37	0_87	57
0_4	40	0_25	31	0_46	27	0_67	37	0_88	58
0_5	36	0_26	30	0_47	29	0_68	38	0_89	56
0_6	37	0_27	29	0_48	30	0_69	40	0_90	52
0_7	36	0_28	29	0_49	29	0_70	41	0_91	58
0_8	35	0_29	28	0_50	29	0_71	41	0_92	56
0_9	34	0_30	26	0_51	31	0_72	42	0_93	58
0_10	33	0_31	30	0_52	28	0_73	46	0_94	54
0_11	34	0_32	30	0_53	29	0_74	47	0_95	56
0_12	32	0_33	29	0_54	30	0_75	48	0_96	53
0_13	32	0_34	30	0_55	31	0_76	51	0_97	52
0_14	30	0_35	27	0_56	31	0_77	52	0_98	52
0_15	31	0_36	29	0_57	32	0_78	51	0_99	52
0_16	31	0_37	28	0_58	32	0_79	51	0100	49
0_17	30	0_38	30	0_59	31	0_80	53	0101	47
0_18	30	0_39	28	0_60	32	0_81	55	0102	46
0_19	30	0_40	29	0_61	34	0_82	57	0103	44
0_20	28	0_41	31	0_62	34	0_83	54	0104	46
0_21	30	0_42	29	0_63	33	0_84	57	0105	43

DATA PAD FOR
HRM-III
OPERATION 2
21

11-6

STS-11/41

DATA PAD FOR
HRM-III
OPERATION 3
22

11-7

STS-11/ETU

CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC
0_1	44	0_22	30	0_43	41	0_64	57	0_85	44
0_2	43	0_23	29	0_44	45	0_65	57	0_86	44
0_3	43	0_24	29	0_45	47	0_66	56	0_87	41
0_4	35	0_25	32	0_46	46	0_67	55	0_88	40
0_5	41	0_26	31	0_47	50	0_68	55	0_89	38
0_6	36	0_27	32	0_48	49	0_69	56	0_90	39
0_7	35	0_28	31	0_49	51	0_70	53	0_91	39
0_8	34	0_29	32	0_50	50	0_71	55	0_92	37
0_9	31	0_30	30	0_51	53	0_72	56	0_93	37
0_10	31	0_31	33	0_52	52	0_73	55	0_94	34
0_11	33	0_32	32	0_53	51	0_74	56	0_95	33
0_12	29	0_33	32	0_54	53	0_75	56	0_96	33
0_13	27	0_34	33	0_55	55	0_76	52	0_97	31
0_14	27	0_35	34	0_56	54	0_77	56	0_98	29
0_15	28	0_36	36	0_57	55	0_78	55	0_99	29
0_16	29	0_37	36	0_58	56	0_79	52	0100	29
0_17	26	0_38	36	0_59	51	0_80	51	0101	29
0_18	25	0_39	37	0_60	56	0_81	51	0102	28
0_19	28	0_40	40	0_61	56	0_82	49	0103	28
0_20	28	0_41	39	0_62	57	0_83	48	0104	29
0_21	28	0_42	43	0_63	56	0_84	46	0105	27

SPAS-01 DEACT

STU EXP

GAS

HRM DATA PADS

CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC	CHANNEL	COUNTS/SEC
0_1	32	0_22	41	0_43		0_64	34	0_85	27
0_2	34	0_23	42	0_44	53	0_65	31	0_86	28
0_3	30	0_24	44	0_45	56	0_66	31	0_87	28
0_4	30	0_25	45	0_46	53	0_67	29	0_88	27
0_5	30	0_26	45	0_47	55	0_68	28	0_89	28
0_6	31	0_27	50	0_48	52	0_69	29	0_90	29
0_7	31	0_28	48	0_49	53	0_70	29	0_91	25
0_8	30	0_29	47	0_50	54	0_71	27	0_92	25
0_9	31	0_30	52	0_51	53	0_72	26	0_93	28
0_10	31	0_31	54	0_52	52	0_73	27	0_94	27
0_11	34	0_32	49	0_53	50	0_74	26	0_95	27
0_12	33	0_33	54	0_54	51	0_75	25	0_96	26
0_13	32	0_34	53	0_55	49	0_76	25	0_97	27
0_14	35	0_35	55	0_56	47	0_77	25	0_98	30
0_15	33	0_36	54	0_57	44	0_78	26	0_99	28
0_16	36	0_37	55	0_58	43	0_79	26	0100	30
0_17	35	0_38	55	0_59	41	0_80	26	0101	29
0_18	36	0_39	58	0_60	40	0_81	26	0102	29
0_19	34	0_40	57	0_61	38	0_82	27	0103	30
0_20	40	0_41	55	0_62	36	0_83	27	0104	32
0_21	39	0_42	54	0_63	36	0_84	26	0105	29

11-8

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